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The biological importance of the Eastern Arc Mountains of Tanzania and Kenya

N.D. Burgess[a,b,c,*], T.M. Butynski[d], N.J. Cordeiro[e,f], N.H. Doggart[g], J. Fjeldså[h], K.M. Howell[i], F.B. Kilahama[a], S.P. Loader[k], J.C. Lovett[l], B. Mbilinyi[a], M. Menegon[m], D.C. Moyer[n], E. Nashanda[j], A. Perkin[g], F. Rovero[m], W.T. Stanley[o], S.N. Stuart[p]

[a]*Conservation and Management of the Eastern Arc Mountain Forests (CMEAMF), Forestry and Beekeeping Division, P.O. Box 289, Morogoro, Tanzania*
[b]*WWF-USA Conservation Science Programme, 1250 24th St. NW, Washington, DC 20037-1193, USA*
[c]*Conservation Biology Group, Zoology Department, Cambridge University, CB2 3EJ, UK*
[d]*Eastern Africa Regional Program, Conservation International, c/o IUCN, P.O. Box 68200, Nairobi 00200, Kenya*
[e]*Field Museum of Natural History, 1400 S Lake Shore Drive, Chicago, IL 60605, USA*
[f]*Tanzania Wildlife Research Institute, P.O. Box 661, Arusha, Tanzania*
[g]*Tanzania Forest Conservation Group, P.O. Box 23410, Dar es Salaam, Tanzania*
[h]*Zoological Museum, Universitetsparken 15, DK-2100, Copenhagen, Denmark*
[i]*Zoology Department, University of Dar es Salaam, P.O. Box 35064, Dar es Salaam, Tanzania*
[j]*Forestry and Beekeeping Division, Ministry of Natural Resources and Tourism, P.O. Box 9372, Dar es Salaam, Tanzania*
[k]*Department of Zoology, the Natural History Museum, Cromwell Road, SW7 5BD, UK*
[l]*Environment Department, University of York, Heslington, York YO10 5DD, UK*
[m]*Sezione di Zoologia dei Vertebrati, Museo Tridentino di Scienze Naturali, Via Calepina 14, I-38100 Trento, Italy*
[n]*Wildlife Conservation Society, P.O. Box 936, Iringa, Tanzania*
[o]*Field Museum of Natural History, 1400 S Lake Shore Drive, Chicago, IL 60605, USA*
[p]*CI/CABS – IUCN/SSC Biodiversity Assessment Initiative, c/o Center for Applied Biodiversity Science, Conservation International, 1919 M Street NW, Suite 600, Washington, DC 20036, USA*

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ABSTRACT

The Eastern Arc Mountains are renown in Africa for high concentrations of endemic species of animals and plants. Thirteen separate mountain blocks comprise the Eastern Arc, supporting around 3300 km^2 of sub-montane, montane and upper montane forest, less than 30% of the estimated original forested area. At least 96 vertebrate species are endemic, split as follows: 10 mammal, 19 bird, 29 reptile and 38 amphibian species. This includes four endemic or nearly endemic species of primate – the Sanje Mangabey, the Iringa Red Colobus, the Mountain Galago and the new Kipunji monkey that forms its own monotypic genus. A further 71 vertebrate species are near-endemic. At least 800 vascular plant species are endemic, almost 10% of these being trees. These endemics include the majority of the species of African violet – *Saintpaulia*, a well-known flowering plant in Western households. An additional 32 species of bryophytes are also endemic. Many hundreds of invertebrates are also likely to be endemic, with data for butterflies, millipedes and dragonflies indicating potential trends in importance. Seventy-one of the endemic or near-endemic vertebrates are threatened by extinction (8 critical, 27 endangered, 36 vulnerable), with an additional seven wide ranging threatened species. Hundreds of plant species are also threatened.

* *Corresponding author:* Tel.: +44 1223 440155.
E-mail address: neil.burgess@wwfus.org (N.D. Burgess).
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Most Eastern Arc endemics are closed-forest specialists and comprise taxa with an ancient history and those of more recent origin, including some possessing ancient affinities with taxa from West Africa, Madagascar, and even South America and Southeast Asia. Mountain block prioritisation for biodiversity conservation shows that Udzungwas, East Usambaras and Ulugurus are the most important blocks, with other important blocks being the Ngurus and West Usambaras. Rankings are correlated closely with the area of remaining forest. Most of the remaining forest is found within nearly 150 Government Forest Reserves, with 106 of these managed nationally for water catchment, biodiversity and soil conservation and where forest exploitation is not allowed. Outside these areas most forest has been cleared, except in small village burial/sacred sites, a few Village Forest Reserves, and inaccessible areas. In most Eastern Arc Mountains the local populations have not encroached beyond the reserve boundaries to develop farms, but forest resources within the boundaries are used for fuel and building materials and some forests are heavily degraded. Fire is also a problem as it enters and destroys forests during the dry seasons. The future of the biodiversity on the Eastern Arc Mountains is closely tied to management policies and capacity of the Tanzania Forestry and Beekeeping Division, Tanzania National Parks Authority, and Kenya Forest Department. Supporting these agencies in their mandated job is an essential conservation investment over the longer term.

1. Introduction

The phrase 'Eastern Arc Mountains', describing a chain of mountains starting in southern Kenya and progressing through eastern Tanzania, first appeared in print in 1985, together with a map of the area (Lovett, 1985). In subsequent years, biological data on the importance of the Eastern Arc Mountains have been increasingly refined and summarised, first by Lovett and Wasser (1993), and later by Burgess et al. (1998a,b) and Newmark (2002). These and other data have been used in several global analyses of biodiversity priority to show that the Eastern Arc Mountains rank among the most important areas of the world for the conservation of endemic birds (ICBP, 1992; Stattersfield et al., 1998), endemic plants (Lovett, 1988; Myers, 1988, 1990; Lovett, 1998a; Mittermeier et al., 1998; Myers et al., 2000; Lovett et al., 2004), and a combined set of taxonomic groups (Olson and Dinerstein, 1998; Brooks et al., 2001; Burgess et al., 2004b). The Eastern Arc is also home to four endemic or near-endemic species of primates – the Sanje Mangabey *Cercocebus sanjei*, Iringa Red Colobus *Procolobus gordonorum*, the Mountain Galago *Galagoides orinus* and the new Kipunji monkey *Rungwecebus kipunji* that is the sole representative of its genus (Davenport et al., 2006) – and most of the known species of African violet – *Saintpaulia* spp. Attempts to factor threat into assessments of conservation priority across the world and across Africa have also shown that the Eastern Arc is amongst the most threatened regions of global biodiversity significance and one where the extinction risk to the fauna and flora is intense, and increasing (Balmford et al., 2001a,b; Brooks et al., 2002; Burgess et al., 2004a,b).

A number of studies have also looked at patterns and priorities among the 13 separate mountain blocks within the Eastern Arc (Burgess et al., 1998b; Baker and Baker, 2002; CEPF, 2003), and some have looked at priorities within single blocks (Rodgers and Homewood, 1982a,b; Johansson et al., 1998; Dinesen et al., 2000). These studies concluded that some of the blocks are more important than others, with the East Usambaras, Ulugurus and Udzungwas consistently being assessed as the most important areas. More recent studies have shown how the prioritisation can be altered by undertaking new fieldwork in poorly known blocks, and also that the overall ranking of the 13 blocks is correlated with both the forest area remaining and the degree of study effort (Doggart et al., 2006).

The primary aim of this paper is to analyse the biological importance of the Eastern Arc Mountains vertebrate fauna, as indicated by the number of endemic and near-endemic endemic species in the various mountain blocks. We use both data published in the peer-reviewed literature and that from unpublished sources provided by taxonomic experts. A second aim is to assess the importance of different blocks for vertebrate species regarded as threatened with extinction (http://www.redlist.org), with lower significance given to this attribute because the Red List assessment process has not been completed for reptiles. A third aim is to compile and present data on other less well known groups to see whether they share similar patterns of importance. This is done for trees, and for some invertebrate groups – butterflies, millipedes, spiders and dragonflies. Prioritisation among the different Eastern Arc Mountain blocks is also examined against one potential explanatory variable – the area of remaining forest. Discussion focuses on hypotheses developed to explain the exceptional biodiversity of these mountains – which revolve around the likely persistence of forest cover over millions of years and the relative importance of ancient relict endemics and recently evolved endemics within the Eastern Arc Mountains.

2. Study area

2.1. *Definition of the Eastern Arc mountains*

The Eastern Arc is defined as a chain of ancient crystalline Precambrian basement mountains, stretching from the Taita

Hills in Kenya to the Udzungwa Mountains in south-central Tanzania, which were uplifted at least 30 million years ago and which are under the direct climatic influence of the Indian Ocean (Lovett, 1990; Lovett et al., 2004). The Eastern Arc is also defined to end at the Makambako Gap – a non-forest region of dry habitat – at the south-western end of the Udzungwa Mountain range. Forested mountains with a similar geology are found further south-west of the Makambako Gap. These 'Southern Rift' forests differ from those of the Eastern Arc because they are not directly under the Indian Ocean climatic regime and are subject to more variable convectional rainfall patterns. They also contain higher percentages of grassland habitat, and while a few representatives of the flora and fauna are shared with the Eastern Arc, the 'Southern Rift" forests have much lower rates of endemism in all taxonomic groups (Lovett, 1993; Burgess et al., 2004a,b).

Following from the above definition, there are 13 separate mountain blocks in the Eastern Arc. These are from north to south: Taita (including Kasigau; in Kenya), North Pare, South Pare, West Usambara, East Usambara, Nguu, Nguru, Uluguru, Ukaguru, Rubeho, Malundwe, Udzungwa, Mahenge (in Tanzania) (Fig. 1; Table 1).

2.2. *Forest categorisation*

The Eastern Arc Mountains range up to 2635 m in altitude (Lukwangule Plateau and Kimhandu Peak in the Ulugurus) and contain a diverse assemblage of habitats. It is expected that prior to major human influence on the landscape, the wetter (eastern and south-eastern) slopes supported a continuous forest cover throughout all elevations, while the drier (western and north-western) slopes supported deciduous woodland at lower elevations and evergreen forest only at higher elevations. Tall evergreen forest was found on the top plateaus well away from the rain-capturing scarps, as a consequence of persistent fog over the highlands during the night. In other parts of the highlands, montane grassland and heathland dominated. A desiccation-adapted flora occurred on rocky outcrops.

On the Uluguru Mountains, the forest formations have been divided into upper montane (1800–2635 m), montane (1250–1800 m) and sub-montane (800–1250 m) forest zones (e.g. Pócs, 1976). Elsewhere the same zones are recognised (Lovett, 1993), but their boundaries occur at somewhat different altitudes – depending on inclination of the terrain, rainfall, distance from the coast, height of the mountains,

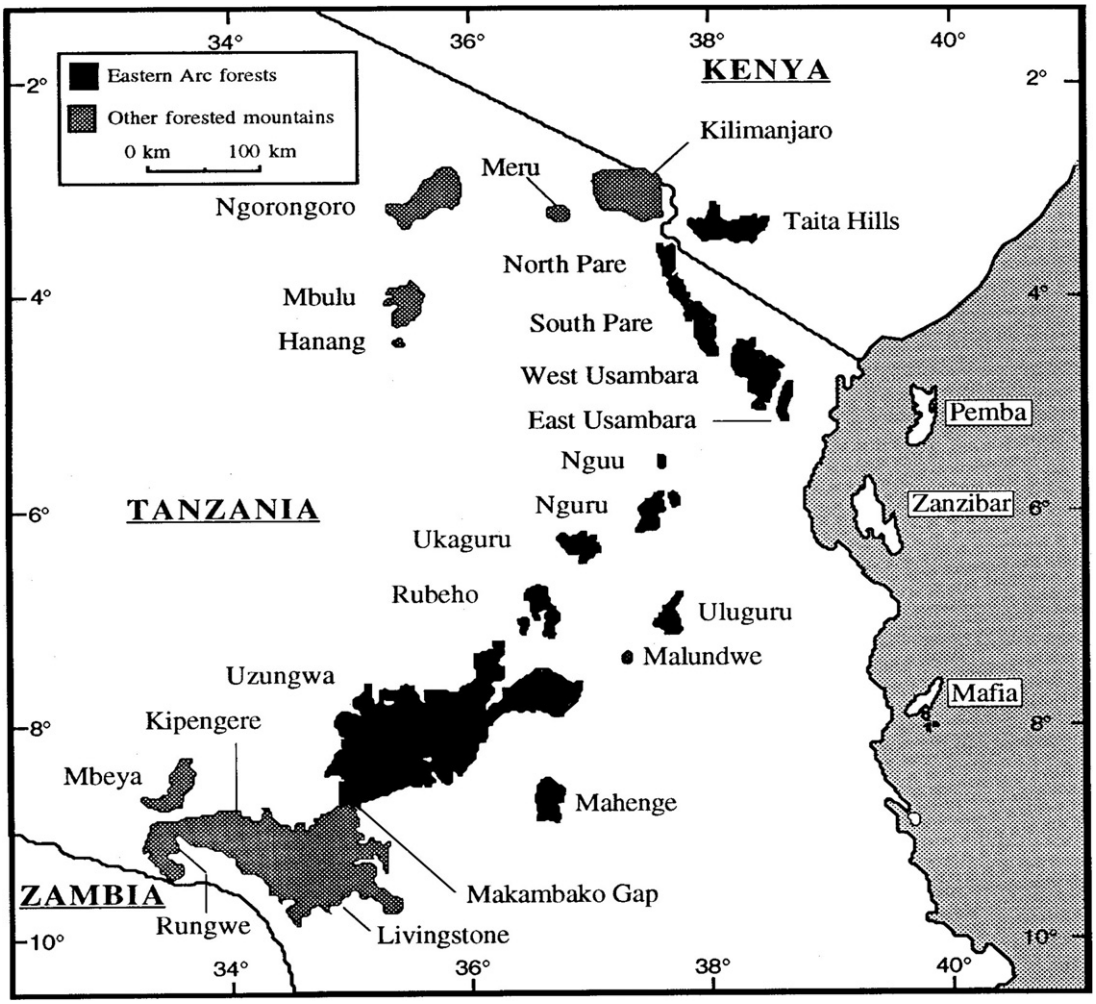

Fig. 1 – Map showing the 13 blocks of the Eastern Arc Mountains of Tanzania and Kenya.

Table 1 – Location, area (km²) and altitudinal range of forested habitats in the Eastern Arc Mountains of Kenya and Tanzania

Sites	Coordinates (degree and minutes)	Forest area (km²) according to Newmark (2002)	Forest area (km²) according to various other published sources (see notes)	Forest area (km²) according to standardised analysis of satellite imagery[s]	Date and type of satellite imagery used[s] Date order for images follows day, month, year	Size of the block (km²)	Altitudinal range of forest (m)
Taita Hills	0325S 3820E	6	3[a,m,r]	3[*]	Not available	Not available	1500–2140
North Pare	0335–0346S 3733–3740E	151	25[b,c]	27	25.10.1999; Landsat TM	453.58	1300–2113
South Pare	0404–0434S 3745–3801E	333	211.1[b]	138	25.10.1999; Landsat TM	1577.73	820–2463
West Usambara	0420–0507S 3806–3841E	547	220[d]	319	25.10.1999; Landsat TM	2506.65	1200–2200
East Usambara	0445–0520S 3826–3848E	413	450[d,e,i]	263	17.01.2000; Spot XS	1082.00	130–1506
Nguu	0527–0538S 3736–3732E	Included in Nguru	140.42[j]	188	17.8.2003; Landsat TM+	1591.00	1000–1550
Nguru	0527–0613S 3726–3737E	647	328.35[b]	297	07.06.2002; Spot XS	1672.90	400–2000
Uluguru	0651–0712S 3736–3745E	528	230[b,h,p]	278[**]	22.02.2000; Spot XS	1477.50	300–2400
Ukaguru	0619–0635S 3653–3703E	184	155.38[b,k]	172	07.07.2000; Landsat TM	1258.80	1500–2250
Rubeho	0648–0722S 3634–3658E	499	654[g,o]	464	07.07.2000; Landsat TM	4636.40	520–2050
Malundwe Hill	0724S 3718E	6	4.5[l]	13	07.07.2000; Landsat TM	1661.50	1200–1275
Mahenge	0837–0838S 3642–3644E	291	5[b,q]	19	25.10.1999; Landsat TM+	2802.29	460–1040
Udzungwa	0722–0843S 3507–3658E	2103	1017[b,f,n]	1353	01.11.1999, 11.10.2003; TM+	16,131.40	300–2580
Total		5708	3443	3534			

a Waiyaki, unpublished (ground survey).
b Lovett and Pócs (1993) (ground survey).
c Cordeiro and Kiure (1995) (ground survey).
d Iversen (1991) (aerial photos).
e Evans (1997) (ground survey).
f Moyer (1992) (remote sensing).
g Fjeldså et al. (1997a,b) (ground survey).
h Svendsen and Hansen (1995) (ground survey).
i Johansson and Sandy (1996) (satellite images and aerial photos).
j Seddon et al. (1995) (ground survey).
k Evans and Anderson (1993) (ground survey).
l Lovett and Norton (1989) (ground survey).
m Tetlow (1987) (ground survey).
n Lovett et al. (2001) (ground survey).
o Doggart et al. (2006) (ground survey).
p Burgess et al. (2002b) (aerial photos and ground survey)
q Frontier-Tanzania (2001–2004) (ground survey).
r Lens et al. (2002) (satellite images and ground survey).
s Mbilinyi and Kashaigili (2005) (satellite images and ground truthing).
* Not included in the study by Mbilinyi and Kashaigili (2005) and hence the figure from the previous column was used.
** Including outlying hills such as Mindu, Nguru ya Ndege, Mkungwe, Dindili and Kitulang'halo.

incidence of cloud cover, etc. For example, the forest zone divisions are at lower elevations in the cloudy and maritime East Usambara Mountains (Moreau, 1966), whereas they are much higher in inland rain-shadow areas, where evergreen forest is limited to top plateaus (>2000 m). At lower elevations (regarded by Pócs, 1976 as below 800 m on the Ulugurus, but below 500 m elsewhere) the sub-montane forest grades in species composition and physiognomy into that of the

Table 2 – Protected areas (National Parks), other reserves (Forest Reserves) and areas of private forest found within the 14 districts of the Eastern Arc Mountains of Tanzania, and number of forestry staff available for management (as of 2004)

District	National Parks (name)	National FR (*n*)	National FR area (km^2)	Local authority FR (*n*)	Local authority FR (km^2)	Village Forest Reserve (*n*)	Village Forest Reserve (km^2)	Private forests (km^2)	Number of foresters
Mpwapwa		4	154.6	0	0	0	0	0	5
Kilolo	Part of Udzungwa Mountains NP	7 (plus 1 proposed)	805.5	0	0	0	0	0	66
Mufindi		6	218.1	15	15.5	2	2.8	134.5	28
Same		2	197.5	7 (plus 2 proposed)	74.2	3 (proposed)	Unknown	0	27
Mwanga		3 (plus 3 proposed)	74.1	0	0	0	0	0	14
Kilindi		11	303.4	0	0	0	0	0	12
Lushoto		16	340.1	7	13.6	11 (proposed)	22.1	5	36
Korogwe		8	110.5	0	0	0	0	35.2	26
Muheza		11 (plus 1 NR and 1 proposed FR)	315.9	0	0	4	9.9	2.1	25
Kilombero	Part of Udzungwa Mountains NP	4	673.4	1	34.7	0	0	0	29
Kilosa	Part of Mikumi NP	8	801.5	0	0	0	0	0	29
Morogoro		8	356.3	2	0.2	0	0	0	42
Mvomero	Part of Mikumi NP	9	317.9	0	0	0	0	0	7
Ulanga		7	49.6	0	0	0	0	0	18

Notes: FR = Forest Reserve; NR = Nature Reserve; NP = National Park.

'transitional' rainforests. Transitional forests are often grouped within the lowland Coastal Forests found along the eastern littoral plain of Africa from Somalia in the north to Mozambique in the south (White, 1983; Burgess and Clarke, 2000). In reality, no hard boundary exists between these two forest types (Lovett et al., 2001) and in some mountain blocks there is a continuum between the Eastern Arc and Coastal Forest types (e.g. East Usambara, Uluguru, Udzungwa).

2.3. *Reserved areas*

Two National Parks support Eastern Arc habitats in Tanzania. The first is the Udzungwa Mountains National Park (1900 km^2) which contains large areas of mountain forest and grassland; the second is Mikumi National Park (1450 km^2) that includes a small area (4 km^2) of montane forest on Malundwe Hill. Both parks have the internationally agreed protected area code IUCN II and are managed by the Tanzania National Parks Authority (TANAPA). Three other areas of the Eastern Arc are gazetted as Nature Reserves, but not given IUCN protected area codes. The first of these is the recently declared (1997) Amani Nature Reserve (83 km^2) managed by the Forestry and Beekeeping Division (FBD) in the East Usambara Mountains, and the second and third are private Nature Reserves, the first within the Mufindi Tea Estate in the Udzungwa Mountains (Lovett and Moyer, 1992) and the second at Mazumbai in the West Usambara Mountains (Redhead, 1981).

The majority of the rest of the Eastern Arc forest in Tanzania is found within various different categories of Forest Reserve. These are managed under two separate administrative structures and are not assigned any IUCN protected area codes. The Tanzania Forestry and Beekeeping Division manages the majority of the larger Forest Reserves for water catchment and biodiversity conservation. These 104 'national' Forest Reserves cover 4718 km^2 and support a mosaic of forest, grasslands, and other habitat types (Burgess and Kilahama, 2005). A further 32 Local Authority Forest Reserves (138 km^2) are managed by the Districts, and approximately six Village Forest Reserves (25 km^2) are managed by villages. In addition there are seven proposed Forest Reserves (611 km^2), and 14 proposed village FRs (22 km^2) that are not legally gazetted. Privately managed forests cover around 177 km^2 and are found at Mazumbai (owned by Sokoine University), and within the tea estates of Ambangulu in the West Usambaras, Mufindi in the Udzungwa Mountains and Amani/Kwamkoro in the East Usambaras (Table 2). Within the human-dominated landscape outside the Reserves and private estates smaller patches of forest remain under traditional village authority. Almost every village has a forest patch for rituals and as a burial grove for its people, but these are generally under 1 km^2 in area and the total area is probably under 100 km^2 (e.g. Mwihomeke et al., 1998; Ylhäisi, 2004).

3. Methods

3.1. *Remaining habitat*

The forest cover data presented are derived from Mbilinyi and Kashaigili (2005), a study undertaken at the Sokoine

University of Agriculture Remote Sensing and GIS laboratory (Morogoro, Tanzania) with technical backing from the Centre for Applied Biodiversity Science at Conservation International (Washington, DC, USA) and National Aeronautics and Space Administration (NASA). The methodology to calculate the forest area in the Eastern Arc is outlined below:

The satellite images used to assess forest cover were selected from a large number of potential images taken during the dry season (June–November) and yielding minimum cloud cover (Table 1). Such images maximise the chances to resolve differences between evergreen forest habitat and deciduous (in the dry season) woodland habitat. The best images were first combined into a composite image covering the Eastern Arc Mountains. Combination involved image rectification undertaken using second order polynomial transformation and nearest-neighbourhood interpolation. Maximum likelihood classifier (MLC) remote sensing classification methodologies were then utilised to develop the initial map of different vegetation types in the Eastern Arc. The supervised classification process involved selecting training sites on the image which represent known land classes. Training was an iterative process, whereby the selected training pixels were evaluated by performing an estimated classification (ALARM command). These ALARM results were evaluated and training samples were refined sequentially. The results of initial field verification were also included at this stage. In order to reinforce the visual interpretability of images, a colour composite (Landsat TM bands 4 5 3) was prepared and its contrast was stretched using a Gaussian distribution function. Furthermore, a 3×3 high pass filter was applied to the colour composite to further enhance linear features, e.g. rivers, and patterns such as cultivation. All image processing was carried out using ERDAS Imagine software.

The resulting map was checked for errors. Examples of typical errors are cloud edges being confused with non-forested areas, water being confused with cloud shadows, etc. At this stage additional sub-classes were added to the set of training data or old, problematic sub-classes were modified. After this a new MLC was run and the process was repeated over several iterations until the map had sufficiently low error. Classified images were then recoded to respective classes i.e. forest, woodland, plantation, etc.

Verification of results was undertaken in two ways, at different times in the process. Firstly, field surveys were undertaken during 2005 in the following Mountain blocks; Uluguru, Ukaguru, Rubeho, Mahenge, Image and Udzungwa. This gathered field data to help with the initial classification process. Second, draft output maps were sent to nine experts familiar with different Mountain Blocks and their comments were used to further refine the classification of the habitat types – especially the differentiation of closed forests and woodlands.

3.2. *Vertebrates*

Data on the vertebrate fauna of the Eastern Arc Mountains are based on the approach presented in Burgess et al. (1998a,b). In this scheme, endemic vertebrates are those confined to the Eastern Arc Mountains as defined here and in the African-wide assessment of 'ecoregions' by the World Wildlife Fund (USA) (Burgess et al., 2004b, 2006). Near-endemic vertebrates are found in the Eastern Arc ecoregion (ecoregion 19 of Burgess et al., 2004b), but also occur in one or more of the following WWF ecoregions – Northern Inhambane–Zanzibar Coastal Forest Mosaic (ecoregion 20), Southern Rift Montane Forest–Grassland Mosaic (ecoregion 74) and/or the East African Montane Forests (ecoregion 18).

For this paper we have significantly updated the biological data in Burgess et al. (1998a,b) with the assistance of key taxonomic specialists. For mammals we added all recently described species and new distributional records from published papers: shrews (Stanley et al., 1998a,b; Stanley and Hutterer, 2000; Stanley et al., 2005a; Stanley and Olson, 2005), rodents (Stanley et al., 1996, 1998a,b); galagos (Honess and Bearder, 1996; Bearder et al., 2003; Grubb et al., 2003; Perkin et al., 2003), monkeys (Jones et al., 2005); duikers (Rovero et al., 2005); Rubeho Mountains (Doggart et al., 2006); Malundwe Mountain (Stanley et al., 2005b); Mahenge Mountains (Frontier-Tanzania, 2001–2004); Uluguru Mountains (Doggart et al., 2005); Udzungwa Mountains (Frontier Tanzania, 2001); East Usambara Mountains (Johansson et al., 1998; Frontier Tanzania, 1999–2002), South Pare Mountains (Stanley et al., 1996, 1998b). Additional distribution data covering several large mammals was taken from Cordeiro et al. (2005), Grimshaw et al. (1995) and unpublished data from the authors. For birds we added data for several newly described species (see Annex 1) and mountain blocks according to the following sources: Uluguru Mountains (Doggart et al., 2005); Rubeho Mountains (Doggart et al., 2006); Nguu Mountains (Seddon et al., 1999a,b); Taita Hills (Brooks et al., 1998; Lens et al., 2002); Udzungwa Mountains (Fjeldså, 1999; Butynski and Ehardt, 2003); Mahenge Mountains (Frontier-Tanzania, 2001–2004); South Pare Mountains (Baker, 2001); Nguru Mountains (Romdal, 2001a), West Usambara Mountains (Lovett and Stuart, 2001); East Usambara Mountains (Cordeiro, 1998; Seddon et al., 1999a,b). Unpublished data was also provided by the authors. For amphibians we used the same procedure of adding recently described species (see Annex 1) and new distributional data as follows: Uluguru Mountains (Doggart et al., 2005); Rubeho Mountains (Doggart et al., 2006); Nguu Mountains (Menegon et al., 2003); Mahenge Mountains (Loader et al., 2003); Udzungwa Mountains (Poynton, 1998; Poynton et al., 1998; Menegon and Salvidio, 2005); and unpublished data from the authors. The reptile data are significantly updated from that in Howell (1993) using Spawls et al. (2001), and more recently described species (see Annex 1) and new distributional data as follows: Nguru Mountains; Nguu Mountains (Menegon et al., 2003); Uluguru Mountains (Doggart et al., 2005) and unpublished data from the authors. The compiled data on vertebrate animals in each Eastern Arc mountain block and nearby forest ecoregions (Annex 1) was used for various analyses, as described below.

We have excluded from our database vertebrate species that have an exclusively lowland forest distribution, even if they are found geographically adjacent to the Éastern Arc Mountain forests. These species are as follows: one bird (*Otus ireneae*), two mammals (*Kerivoula africana* and *Galagoides cocos*), four amphibians (*Mertensophryne micranotis*; *Afrixalus*

sylvaticus, *Hyperolius rubrovermiculatus* and *Stephopaedes usambarae*), and two reptiles (*Lygodactylus williamsi* and *Prosymna semifasciata*).

3.3. Trees

A list of Eastern Arc endemic large trees and their distribution was compiled using references cited in Lovett (1998a) supplemented by more recent field observations by Jon Lovett (Annex 2). A large tree was defined as greater than 10 m tall and/or 20 cm diameter at breast height. The definition of near-endemic tree species followed the same methodology as for vertebrates (see above). Species with disjunct distributions distant from the Eastern Arc are not included. Species lists for the Taita Hills, Usambara Mountains, Uluguru Mountains and Udzungwa Mountains are more complete than other mountain blocks due to greater research activity. Although not used for analysis we also reviewed information on endemic bryophyte species (Pócs, 1998).

3.4. Analysis of biodiversity priority

Two kinds of ranking methods were used to assess the priority of the different component blocks of the Eastern Arc Mountains. The first method uses the summed numbers of strictly endemic and/or near-endemic vertebrates and tree species for each of the 13 Eastern Arc Mountain blocks. The second method corrects the species data for the effects of forest area and thus aims to reduce the potential bias in the prioritization approach – where larger forests contain more species simply due to the species–area relationship (Rosenzweig, 1995).

Area correction was performed using the equation:

$$SA = S/A^z$$

where z is the species–area exponent, S is the number of species, A is area (km^2) and SA is the number of species corrected for area. We set z = 0.2 as this corresponds to empirical results for a wide variety of taxa and locations in mainland terrestrial ecosystems (Rosenzweig, 1995).

3.5. Correlation between biological importance and forest area

Across the Eastern Arc Mountains there is great variation in the area of forest remaining in different mountains. We used Spearman Rank Correlations to examine whether the biological importance of each Eastern Arc Mountain block for endemic vertebrates and trees (uncorrected for area) is explained by the area of remaining forest habitat.

4. Results

4.1. Forest area assessment

Our analysis of remote sensing imagery indicates that around 3534 km^2 of forest was found in the Eastern Arc Mountains in the late 1990s/early 2000s. This is a similar estimate to that of 3443 km^2 derived by Burgess et al. (1998a,b) using estimates from a variety of published papers (see Table 1). It is less than the estimate of 5708 km^2 for 'natural forest' derived from a landcover map of Tanzania produced using 1995 remote sensing images processed by Hunting Technical Services of the UK (Newmark, 1998; updated by Newmark, 2002) (Table 1). We use the estimate of 3534 km^2 of forest for all further analysis in this paper. The methods used do not allow us to assess the quality of that forest, but clearly distinguish natural forest from woodland and tree plantations.

4.2. Eastern Arc endemic species

4.2.1. Vertebrates

Ninety-six species of vertebrates are endemic to the Eastern Arc Mountains (Annex 1). Of these, 73 (76%) are dense forest specialists and only two (2%) occupy non-forest habitats. Most of the endemic species are sedentary within the Eastern Arc forests, with only a few of the bird species undertaking seasonal migrations as temperatures fall in these mountains during the austral winter months (July–September) (Burgess and Mlingwa, 2000; Romdal, 2001b).

A further 71 species of vertebrate are near-endemic to the Eastern Arc Mountains. Of these, 28 are also found in the lowland Coastal Forests, 46 also range south into the Southern Rift, and 10 are also found on the younger volcanic highlands of northern Tanzania and/or Kenya (some occur in more than one of these three broader regions). The majority of these species are also forest-dependent (45 species; 63%), but some (6 species; 8.5%) occupy non-forest habitats. A few of the near-endemic species also migrate out of the Eastern Arc Mountains, for example the Blue Swallow *Hirundo atrocaerulea*.

4.2.2. Trees

A total of 68 endemic or near-endemic trees are recorded for the Eastern Arc. These tree species occur throughout the elevation and moisture range of the forests, but higher numbers are found in wetter forests. Many of the lowland forest species of the Eastern Arc also occur in coastal forests to the east (Lovett, 1998b).

4.3. Threatened species in the Eastern Arc mountains

4.3.1. Vertebrates

Most of the birds, mammals and amphibians of the Eastern Arc have been assessed against the IUCN Red List criteria – quantifying their degree of threat (http://www.redlist.org, November 2005). Seventy-one of the Eastern Arc endemic or near-endemic vertebrates are threatened by extinction (8 critical, 27 endangered, 36 vulnerable (and 8 data deficient and two near-threatened)) with seven other more wide ranging threatened species. Some of the newly described species (particularly of birds and mammals) are not yet included on the Red List because they have not been assessed. These omissions include three newly described species of mammal (*Congosorex phillipsorum*, *Hylomyscus arcimontensis* and *R. kipunji*, the latter being an unusual new monotypic genus: Davenport et al., 2006), species of *Nectarinia* sunbirds (Bowie et al., 2004) and *Turdus* thrushes (Bowie et al., 2005), and an akalat – *Sheppardia aurantiithorax* (Beresford et al., 2004). Most reptiles have also not been assessed against Red List criteria and many

would be expected to qualify given their small ranges and the extensive collection of some (e.g. chameleons) for the pet trade.

4.3.2. *Trees*

The Red List of threatened tree species for the Eastern Arc Mountains was reviewed in 2003 and was regarded as too incomplete to be used for analysis (CEPF, 2003; Gereau and Luke, 2003). Due to this shortcoming we did not attempt an analysis of threatened tree species among the various Eastern Arc Mountain blocks. However, we know that many of the Eastern Arc endemic tree species are threatened and some may have already become extinct – for example the tree *Platypterocarpus tanganyikensis* (a monotypic genus) was only known from an area of forest in the West Usambara Mountains that was cleared shortly after Tanzania's independence in 1963. This tree species has not been relocated since (Lovett and Stuart, 2001).

4.4. *Biodiversity priorities*

4.4.1. *Vertebrates*

The Udzungwa Mountains have the largest number of single-block endemic (found in no other forest blocks) vertebrate species (17 species), followed by the Uluguru (13 species), the Taita Hills (6 species), the West Usambara (5 species) and the East Usambara (4 species) (Fig. 2a). All other blocks have two or less single block endemic species, and four blocks have none at all. When corrected for area, the Uluguru Mountains and the Taita Hills rise marginally above the Udzungwas in terms of single-block endemic vertebrates per unit area of forest habitat remaining (Fig. 2a).

In terms of Eastern Arc endemic vertebrate species, the Uluguru Mountains have the largest number of vertebrate species (44 species), followed by the Udzungwa (41 species), the East Usambara (35 species), the West Usambara (22 species), the Nguru (20 species) and the Rubeho (12 species) (Fig. 2b). All other sites have 10 or fewer Eastern Arc endemic

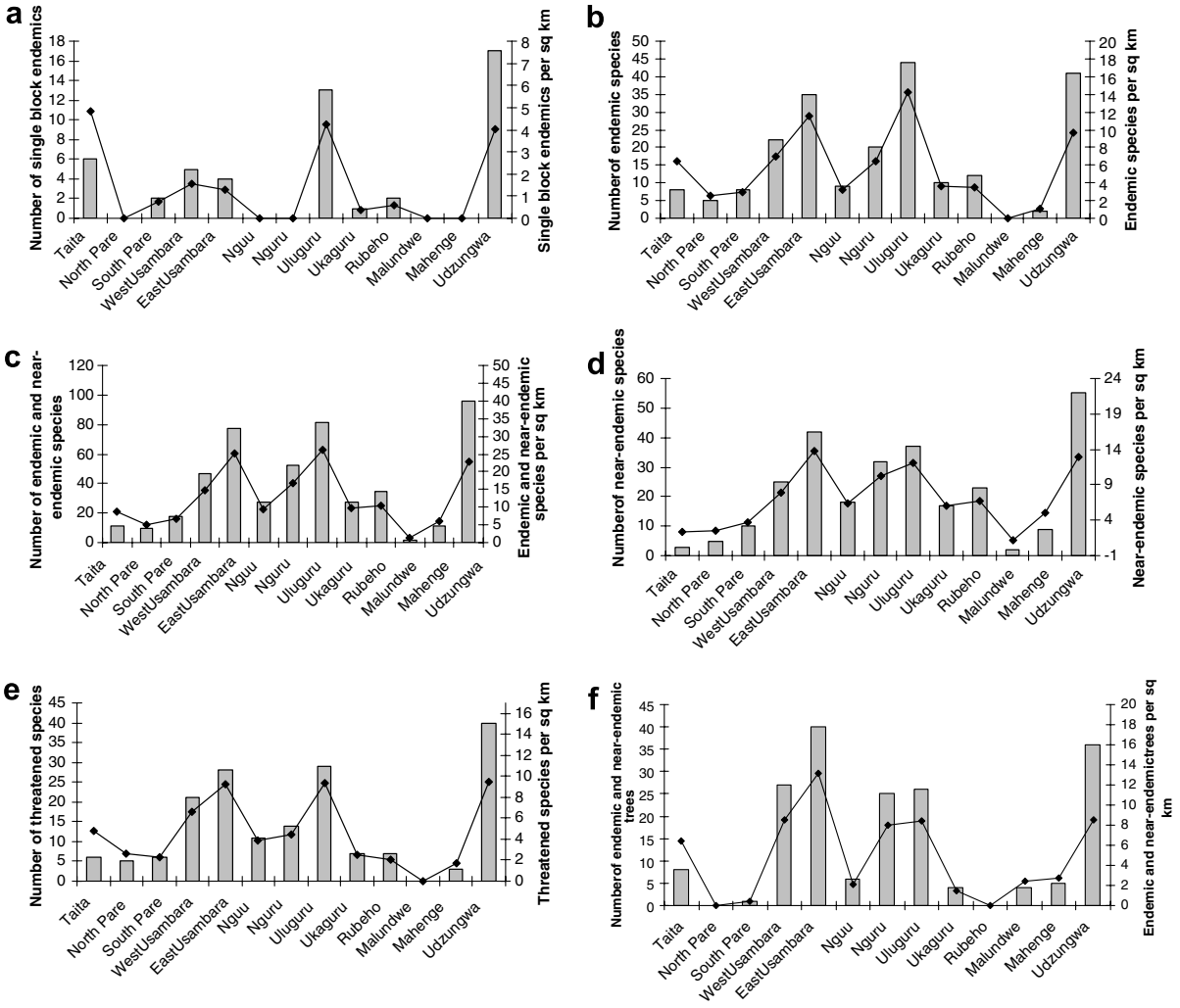

Fig. 2 – Ranked importance for vertebrates and large trees of the 13 mountain blocks of the Eastern Arc Mountains (grey bars = uncorrected species data; black lines and diamonds = species data corrected for forest area). (a) Single block endemic vertebrate species; (b) Eastern Arc endemic vertebrate species; (c) Endemic and near-endemic vertebrate species; (d) Near-endemic vertebrate species; (e) Threatened vertebrate species; (f) Numbers of endemic and near-endemic tree species. Mountain blocks are arranged left to right from north to south in the Eastern Arc.

vertebrate species, with the North and South Pare Mountains and Mahenge Mountains being particularly impoverished. When corrected for variations in forest area, the Uluguru Mountains become of the highest importance for the conservation of Eastern Arc endemic vertebrate species (Fig. 2b).

When endemic and near-endemic vertebrates are combined, the Udzungwa Mountains have the largest number of vertebrate species (96 species), followed by the Uluguru (81 species), the East Usambara (77 species), the Nguru (52 species), the West Usambara (48 species), the Rubeho (35 species), the Ukaguru and Nguu (27 species) (Fig. 2c). Of lowest importance on this scale is Malundwe Mountain with two Eastern Arc endemic or near-endemic species (but virtually no research has been done there). When adjusted for differences in forest area, the Uluguru and East Usambara Mountains are the most important sites for endemic and near-endemic species (Fig. 2c). Similar patterns are seen with near-endemic species (Fig. 2d).

Finally, when the number of Threatened species is used as the measure of importance, the following priorities are obtained: Most important is the Udzungwa Mountains (40 species), followed by the Uluguru (29 species) and East Usambara (28 species), and West Usambara (21 species) (Fig. 2e). When adjusted for variations in forest area, the order of importance of these mountains remains the same (Fig. 2e).

4.4.2. *Trees*

The number of endemic and near endemic trees varies considerably among blocks across the Eastern Arc Mountains (Fig. 2f). The highest number of Eastern Arc endemic/near endemic trees are found in the East Usambara (40 species), Udzungwa (37 species), West Usambara (27 species) and Uluguru (26 species) Mountains (Fig. 2f; Annex 2), which are all well studied blocks. This ranking changes a little when the number of endemic and near-endemic trees is corrected for the remaining area of forest in these blocks (Fig. 2f). Under this analysis the most important forests are those of the East Usambara Mountains, followed by the West Usambara, the Udzungwa, the Uluguru and the Nguru Mountains. The small forests of the Taita Hills are also important in terms of numbers of species in a very small area of forest, as are those of Mahenge. The other mountain blocks are all poorly known, and none are known to contain more than six endemic or near-endemic trees, with Rubeho and North Pare having no known endemics. It is likely that the number of endemic trees in the Nguu, Ukaguru, Rubeho, North Pare and Mahenge Mountains will increase as botanical exploration continues.

4.5. *Relationship between vertebrate species importance and forest area*

There is a high correlation between the vertebrate importance of an Eastern Arc Mountain block and the area of forest remaining. Positive correlations are found between forest area and (1) numbers of endemic plus near-endemic species (Spearman rank correlation coefficient $r_s = 0.862$; $P < 0.0001$), (2) numbers of Eastern Arc endemic species (Spearman $r_s = 0.831$; $P < 0.0001$), and (3) numbers of Red List species (Spearman $r_s = 0.815$; $P < 0.001$). The Red List correlation is easily explained as a small geographical range is one of the criteria within the red listing process.

5. Discussion

This paper demonstrates that the Eastern Arc Mountains are of exceptional importance for endemic species of vertebrates and trees in Africa. It also shows how the mountain blocks within the Eastern Arc attain different importance scores for the conservation of species vertebrates and trees. The Uluguru Mountains, East Usambara Mountains and Udzungwa Mountains consistently emerge as the most important blocks for vertebrates and trees, whereas the Nguru and West Usambara Mountains also figure as important for tree species. The prioritisation results are correlated strongly with the area of remaining forest.

In the following sections we discuss whether (1) the high rates of endemism seen in vertebrates and trees are also found in other taxonomic groups, (2) outline some of the hypotheses put forth to explain why there is so much endemism in the Eastern Arc, and (3) present some suggestions on where survey effort needs to be focussed in the future to obtain a better picture of the patterns of endemism in the Eastern Arc. Finally, we present the conservation challenges facing the Eastern Arc Mountains of Tanzania and the work that is ongoing to try and ensure the long term conservation of the natural habitats of the Eastern Arc – and hence the survival of the endemic species that rely on them.

5.1. *Additional endemic vertebrates and plants*

We still do not have a complete inventory of the endemic species of vertebrates and plants in the Eastern Arc Mountains. New species (and genera) are still regularly being discovered. Within the plants this includes new genera like *Kihansia* (Cheek, 2004), and new species in well-known groups such as coffee (Davis and Mvungi, 2004). More than 15 new vertebrate species are also in the process of scientific description, including: one *Bradypodion* and one *Urocotyledon* from Mahenge, two new *Nectophrynoides* and one *Probreviceps* from Ukaguru (one of the *Nectophrynoides* from Ukaguru has recently been named as *N. laticeps* – Channing et al., 2005), three new *Nectophrynoides* from Uluguru, two *Nectophrynoides*, three *Callulina*, one *Arthroleptis* and one *Probreviceps* from Nguru, and one *Afrixalus* and one *Arthroleptis* from Udzungwa.

Detailed DNA and morphological analysis of existing species also seems likely to further increase the number of taxa within these mountains. As examples, molecular (and morphological) variation in bird species distributed across a number of mountain blocks indicates that they should be split into allo- or parapatric component species; namely *Artisornis metopias*, *Batis mixta* (with populations from Ukaguru and Uluguru towards the south west representing an unnamed species), *Modulatrix stictigula*, *Illadopsis rufipennis* and *Stactolaema olivacea*. And finally in the mammals, there is a distinctive sub-species of the genet *Genetta servalina lowei* that is confined to the Udzungwa Mountains (De Luca and Mpunga, 2002), Kanga Forest Reserve in the Nguru Mountains and Uluguru North in the Uluguru Mountains (F. Rovero, unpublished). This may also, with further work, turn out to be a full species.

5.2. *Endemism in other taxonomic groups*

5.2.1. *Invertebrates*

The invertebrate fauna of the Eastern Arc is more poorly known than the vertebrate fauna. However, the available information suggests that many species of invertebrate are confined to a single Eastern Arc Mountain block. For example, Scharff (1992) shows that single site endemism for linyphiid spiders is over 80%. Moreover, for carabid beetles the Uluguru Mountains have 95% endemism (Basilewsky, 1962, 1976), and for harvestmen arachnids this site has 88% endemism (Scharff et al., 1981). Some of the patterns known for individual invertebrate groups are outlined below.

5.2.2. *Odonata (dragonflies and damselflies)*

Three odonate species are endemic to the Eastern Arc (*Platycypha auripes*, *Amanipodagrion gilliesi* and *Micromacromia miraculosa* – the last two are East Usambara endemics). Two near-endemic species found in the Eastern Arc are *Umma declivium* (Eastern Arc and north Malawi) and *Chlorocnemis abbotti* (Eastern Arc and Kilimanjaro) (Clausnitzer, 2001). Some of these represent genera that are more widespread in the Central and West African forests. The endemic Eastern Arc Odonata species are found in forest habitats and breed in montane streams, or in small waterfilled holes in tree-trunks. Three coastal forest endemics that may perhaps range into the lowlands of the Eastern Arc are *Coryphagrion grandis* (Gondwana relict with nearest relatives in Central and South America), *Hadrothemis scabrifrons* (relict form also found in coastal Gabon and Cameroon), and *Thermochoria jeanneli* (coastal swamp forest) (Clausnitzer, 2001).

5.2.3. *Lepidoptera (Butterflies and moths)*

At least 43 species of butterflies are endemic to the Eastern Arc and contiguous forests in their foothills (De Jong and Congdon, 1993; Congdon et al., 2001). A further 35 species are only found on the higher altitude grasslands of the Eastern Arc and further south into the Southern Highlands of Tanzania and into Malawi. The most important Eastern Arc blocks in terms of endemic butterflies are the Rubeho (13 species), Udzungwa (9 species), Usambara (7 species), Uluguru (7 species), and Nguru (4 species). The forest butterfly fauna also has genera that are representative of groups which are more diverse in the Central and West African rainforests.

5.2.4. *Millipedes*

Hoffman (1993) outlined the state of knowledge of the Eastern Arc millipede fauna, showing that the East Usambaras, Udzungwas and Ulugurus (the only areas where inventories have been compiled) support at least 26 species and 10 genera endemic to one or other of these mountains. New collections from the East Usambara Mountains (Frontier Tanzania, 1999–2002), Uluguru Mountains (Doggart et al., 2005) and Udzungwa Mountains (Frontier Tanzania, 2001) hold additional new genera and species (Hoffman, pers. comm.). It is likely that the number of endemic genera and species will rise significantly with further research.

5.2.5. *Bryophytes*

The Eastern Arc Mountains support a diverse assemblage of bryophytes, with around 700 species recorded (Pócs, 1998). At least 32 species are endemic (5%). Although this level of endemism is low compared with vascular plants, it is high compared with the bryophyte flora of many other areas. A number of monotypic endemic genera are also present, for example *Cladolejeunea* and *Neorutenbergia*. A notable feature of the bryoflora is the high number (45 species, 6%) of Lemurian (Madagascan) species within the assemblage, which reaches its peak in the Uluguru Mountains (40 species). The bryoflora of the Usambara and Uluguru Mountains is quite well known, but information is scanty to non-existent for the other Eastern Arc mountain blocks (Pócs, 1998).

5.3. *Possible reasons for the exceptional rates of endemism*

Why is there such a concentration of endemism in the Eastern Arc Mountains? High level of endemism in East Africa has traditionally been explained by ancient, isolating processes related to the uplift of mountains during the Miocene (Lovett, 1993). These isolating processes would be predicted to result in species replacement patterns that are congruent across many evolutionary lineages, something that does not seem to be supported by recent studies (Bowie, 2003; Bowie et al., 2004). A first step towards understanding the processes responsible for such high endemism in the Eastern Arc has been taken by Jetz et al. (2004), who examined whether endemism in an area exceeds what can be explained from simple null models based on stochastic effects. Jetz et al. (2004) show that the Eastern Arc Mountains, and the Usambara and Udzungwa Mountains in particular, have significantly more endemic species than expected by chance, or by environment and topography alone. These results were interpreted as a consequence of stable local conditions, but the analysis could not separate to what degree the pattern can be attributed due to local speciation or to species persistence (locally low extinction or high speciation rates). Other kinds of evidence provide information about the probable historical processes operating in the Eastern Arc.

5.3.1. *The Arc is as a centre of speciation*

One of the possible explanations for the high number of endemics in the Eastern Arc is that the area has had elevated rates of speciation *in situ*. Various plant groups show remarkable local radiations, for instance *Impatiens* spp. in the Uluguru and *Begonia* spp. in the Udzungwa Mountains. For *Saintpaulia* there is a strong support for recent diversification of local populations in the Usambara Mountains (Lindqvist and Albert, 2001). Other on-going studies suggest a strong degree of recent genetic differentiation of populations of vertebrates inhabiting different highlands (e.g. Bowie, 2003 and in litt. for birds; Perkin et al., 2003 for galagos; Matthee et al., 2004 for leaf chameleons; Loader et al., 2004 in litt. for amphibians; E. Verheyen in litt. for rodents). Molecular studies also suggest both a considerable amount of gene-flow between populations inhabiting different tracts of highland forest, but also some gene flow breaks, which in some cases appear to correspond to physical barriers (Beresford et al., 2004; Stanley and Olson, 2005), but in other cases are situated in an area with no obvious physical barriers (Bowie et al., 2004; Fjeldså et al., in press).

5.3.2. *The Eastern Arc is as an area where species avoid extinction*

It has been suggested that the forest habitats have persisted in the EAM for a prolonged period, even during particularly extreme climatic phases (Lovett, 1993). This ecological stability is thought to have promoted the persistence forest species and overall reducing rates of extinction (Lovett and Wasser, 1993; Fjeldså and Lovett, 1997). The direct evidence for permanence of forest is lacking, but there is strong circumstantial evidence.

Firstly, a number of the genera and species in the Eastern Arc Mountains are known to be genetically ancient. For example, DNA analysis of forest birds indicates that some species derive from lineages stretching back to the early Miocene (c.f. 25 million years ago) (Fjeldså, 1994; Fjeldså and Lovett, 1997; Barker et al., 2004; Fuchs et al., 2005). Some of these species have their strongest affinities with others in forested areas in Southeast Asia; for example the Udzungwa partridge *Xenoperdix udzungwensis* (Dinesen et al., 1994). Others may date back to when there was forest cover across Africa, in the middle and upper Miocene (Axelrod and Raven, 1978) as DNA analyses of some of the isolated eastern bird subspecies show they are divergent from their relatives in the Central Congolian forests (Roy, 1997; Roy et al., 1997; Beresford, 2003).

Secondly, a number of taxonomic groups found in the EAM contain members (or sometimes the entire group) that are often referred to as being 'primitive', i.e. extant members are found on more basally branching parts of a phylogenetic tree. For example, in mammals, the elephant shrews and galagos are often considered, respectively, as early diverging macroscelidean and prosimian lineages (Kingdon and Howell, 2005; Bayes, 1998; Martin, 2003; Fjeldså et al., 2005; Masters et al., 2005). These 'primitive' groups that are also referred to as ancient relict lineages, are well represented in the Eastern Arc forests and, therefore, suggest a prolonged history of forest habitats (Burgess et al., 1998a,b). Similarly, the amphibian fauna of the Eastern Arc contains a diverse number of taxa, many of which are thought to share affinities with species found restricted to distant montane regions of Africa (e.g. bufonids, brevicipitines and caecilan lineages) (Nussbaum, 1985; Poynton, 1999; Wilkinson et al., 2002). Within the invertebrates, Hochkirch (1998) presents information that indicates an ancient history for the grasshoppers of the Eastern Arc. In addition the mollusc fauna contains evidence of ancient faunal connections to Madagascar (Emberton et al., 1997), as does the vascular plant flora (Lovett and Friis, 1996) and the bryophyte flora (Pócs, 1998). Further evidence of the ancient nature of the Eastern Arc fauna is provided by comparisons with the visually similar forests at comparable altitudes on the geologically recent (less than 2 million years old) volcanoes of the region (e.g. Kilimanjaro, Meru, Hanang). All the Eastern Arc forested blocks have much higher rates of endemism than those of these volcanic mountains (see e.g. Scharff, 1992; Pócs, 1998) – and most importantly - the relict species and biogeographical connections to Asia, Congo Basin and Madagascar are lacking in the flora and fauna of the recent volcanoes.

Thirdly, despite there being strong evidence that climatic regimes in East Africa highly fluctuated, and as a result so did the floral composition (Trauth et al., 2005), it is likely that montane habitats, such as those in EAM, were subject to less intensive climatic changes and remained ecologically stable. The elevated topography afforded montane regions more stable climates (Lovett, 1993), buffering forest habitats during extreme arid phases. Marine drill-core data has suggested that the coastal waters of Tanzania were less influenced by Pleistocene climatic changes than elsewhere (Prell et al., 1980), maintaining warm and seasonally humid conditions in the coastal regions and presumably the near-shore Eastern Arc Mountains. Long-term forest stability, as indicated by fossils or climatic indicators has not been investigated directly from any site in the Eastern Arc, and this remains an important area of future research for understanding the persistence of forest habitats in the area. Within the period covered by rainfall records, the African climate has shown marked annual fluctuations in both wet and dry areas, with the climate in some places having a much greater inter-annual variability than others (Nicholson, 1994; Owen et al., 1990; Trauth et al., 2005). However, the Eastern Arc Mountains stand out for having a stable recent climate within an analysis of 10 years meteorological satellite climate data, and it has been postulated that this stability has persisted over the long term (Fjeldså et al., 1997a,b).

5.4. *Conservation priorities*

Among the 13 Eastern Arc Mountain blocks the most important blocks seem robust to the addition of new data. The top three blocks have not changed since the analysis of Burgess et al. (1998a,b) – and do not change when using alternative forest area estimates (e.g. Newmark, 1998, 2002) – with the East Usambara, Uluguru and Udzungwa consistently being the most important blocks. Plants also indicate the same three areas as having the highest importance; for example the Uluguru has more than 135 endemic plant species (Burgess et al., 2002) and the East Usambaras more than 100 endemic species (Iversen, 1991). The ranking of Eastern Arc blocks further down the prioritized list has, however, been influenced by the discovery of new species through undertaking new research in poorly known mountain areas – e.g. the Rubeho Mountains (Doggart et al., 2006). This new research has resulted in some areas (notably the Nguru and the Rubeho Mountains) becoming more important for conservation investment.

5.5. *Conservation issues*

The majority of the Eastern Arc Mountains are found in Tanzania and a number of issues affect their effective conservation. These issues are similar to those affecting the Taita Hills of Kenya, where only 3 km^2 of fragmented forest remains (Lens et al., 2002).

In Tanzania, the future of the biodiversity of the Eastern Arc Mountains is closely tied to the management capability and approach of the Forestry and Beekeeping Division (FBD) of the Ministry of Natural Resources and Tourism, the (parastatal) Tanzanian National Parks Authority (TANAPA), and the District Natural Resource Departments. The majority of the remaining forest is managed by these agencies. Ultimately, the conservation of the forests will also depend on the attitudes, wishes and practices of the hundreds of rural communities living adjacent to the reserves.

The Forestry and Beekeeping Division of the Tanzanian government is working to improve the conservation status of the Eastern Arc Mountains in a number of ways. Starting from 2004, the Tanzanian government has initiated the process to include the Eastern Arc Mountains on the list of natural World Heritage Sites. The initial proposal was submitted in 2005 and a letter received from UNESCO in January 2006 confirmed that the Eastern Arc has been placed on the Tentative List of World Heritage Sites. The government is now working towards developing and submitting the full proposal dossier for this site – which will be made up on a number of different forest areas across this 'archipelago'.

In addition Forestry and Beekeeping Division has also undertaken a detailed analysis of the biological values of the various blocks and reserves within the Eastern Arc and has identified a number of areas that might be upgraded from 'protective Forest Reserves' to 'nature Forest Reserves'. These are the Nilo Forest Reserve in the East Usambara Mountains, the Uluguru North and Uluguru South Forest Reserves in the Uluguru Mountains, the West Kilombero Scarp Forest Reserve in the Udzungwa Mountains, and the Nguru South Forest Reserve in the Nguru Mountains. Active attempts to upgrade the status of these areas to Nature Reserve are now underway for all but the South Nguru FR.

To further recognise the importance of the network of Forest Reserves in the Eastern Arc, the Forestry and Beekeeping Division is working with the IUCN World Commission on Protected Areas (WCPA) to code each Forest Reserve in the Eastern Arc according to IUCN protected area categories. Over 100 reserves have now been provisionally coded against these categories, with most falling under category IV (habitat/species management area). The full list and an accompanying map will be submitted to IUCN WCPA during 2006.

Finally, the government is also working to gazette some of the reserves that have been proposed for a number of years, but never legally declared. There are seven proposed reserves in the North Pare, South Pare, East Usambara and Udzungwa Mountains that cover around 62,000 ha of Eastern Arc forest, grassland and some woodland habitats. Their declaration would be an important addition to the network of reserves in this area (http://www.easternarc.or.tz).

A government analysis of problems affecting the management of the Eastern Arc reserve network in Tanzania has shown that the key constraints to effective conservation are the lack of long-term availability of funding and inadequate management capacity. Apart from meagre salary support, the Tanzanian government (both central and local) provides about $50,000 USD as operational funding to the 340 government staff who are tasked with the management of over 7000 km^2 of Forest Reserves of the Eastern Arc (Burgess and Kilahama, 2005) (Table 2). The funds available from TANAPA to its two National Parks containing Eastern Arc mountain forest (Udzungwa and a small area in Mikumi) are much greater than that allocated by FBD.

We believe that several possibilities exist to expand sustainable financing of Eastern Arc Mountains conservation within Tanzania and Kenya. One promising avenue involves payments for ecosystems services, which would create mechanisms that return funds from water users to the forest managers and surrounding communities. The Eastern Arc provides drinking water for at least 60% of the urban population of Tanzania, and is the source for over 90% of the nation's hydroelectricity generation capacity (which is around 50% of total power production). A recent calculation estimates the annual total economic value of the Eastern Arc as at least $620 million (Government of Tanzania, 2004), but the water values are not well reflected in these estimations and the actual values to the Tanzanian economy might be significantly greater. Another funding avenue that is developing slowly is to direct the tourism away from the northern circuit of national parks like the Serengeti, Ngorongoro Crater and Tarangire systems toward the Eastern Arc Mountains and coastal zone. This venture requires adequate global and national marketing, where culture and biodiversity other than large mammals offer tourists a different type of exploration that could generate money for local economies. The government and private sectors are working on this aspect of tourism for the Eastern Arc Mountains, and as more local communities are involved, the more likely the harmonisation of conservation will be achieved.

In conclusion, the Eastern Arc Mountains are an area of exceptional importance for biodiversity conservation. The majority of the forest is located within national Forest Reserves that are managed for water catchment. Despite the pressures, Forest Reserve boundaries, where they are clearly defined, are mostly respected by the local people. However, the funds available to the managers of the Forest Reserves are insufficient. This makes management problematic and allows significant illegal activities to take place within the forests (timber cutting etc). The future of the forest resource on the Eastern Arc Mountains is tied to the management capacity of the Forest and Beekeeping Division (catchment forest section), to the District Natural Resource offices in the 14 Districts across the Eastern Arc, and to the attitudes and practices of the hundreds of thousands of people who live within a few kilometres of the forest boundaries.

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Appendix 1. Distribution of endemic and near-endemic vertebrates across the Eastern Arc Mountains

Species	Authority	Ende-mism	Threat status (November 2005)	Forest	Taita	North Pare	South Pare	West Usambara	East Usambara	Nguu	Nguru	Uluguru	Ukaguru	Rubeho	Malundwe	Mahenge	Udzungwa	Coastal Forests from Kenya to Mozambique	Kilimanjaro, Meru and/or Kenya Highlands	Southern Rift (inc. Rungwe, Matengo, Namuli, Nje, Malawisi)
Birds																				
Andropadus fusciceps	Shelley (1893)***	NE	LC	FF						x	x	x	x	x		x	x			x
Andropadus masukuensis	Shelley (1897)***	NE	LC	FF			x	x	x	x	x	x	x	x		x	x			x
Andropadus milanjensis	Shelley (1896)***	NE	LC	FF	x	x	x	x	x	x	x	x	x	x			x		x	x
Anthreptes pallidigaster	Reichenow (1905)	NE	EN	F					x								x	x		
Anthreptes rubritorques	Sclater and Moreau (1935)	E	VU	FF				x	x	x	x	x					x			
Apalis chariessa	Reichenow (1879)	NE	VU	FF								x					x	x		x
Apalis chapini	Friedmann (1928)	NE	LC	FF							x	x	x	x			x			x
Apalis fuscigularis	Moreau (1938)	E	CR	FF	x															
Arcanator orostruthus	Vincent (1933)	NE	LC	FF					x								x			x
Artisornis moreaui	Sclater (1931)	NE	CR	FF					x											x
Artisornis metopias	Reichenow (1907)	NE	LC	FF				x	x		x	x	x	x			x			x
Batis mixta	Shelley (1889)	NE	LC	FF		x	x	x	x	x	x	xn	xn	xn			xn	x	x	xn
Bubo vosseleri	Reichenow (1907)	E	VU	FF			xu	x	x		x	x		x			x			
Cisticola njombe	Lynes (1933)	NE	LC	NF										x			x			x
Cisticola nigriloris	Shelley (1897)	NE	LC	NF										x			x			x
Cinnyricinclus femoralis	Richmond (1897)	NE	VU	FF	x	x													x	
Hyliota usambarae	Sclater (1932)	E	EN	F				x	x											
Laniarius fuelleborni	Reichenow (1900)	NE	LC	FF				x			x	x	x	x			x			x
Lanius marwitzi	Reichenow (1901)	NE	LC	f									x	x			x			x
Malaconotus alius	Friedmann (1927)	E	EN	FF								x								
Modulatrix stictigula	Reichenow (1906)	NE	LC	FF				x	x		x	x	x	x			x			x
Nectarinia loveridgei	Hartert (1922)	E	LC	FF								x								
Nectarinia moreaui	Sclater (1933)	E	LC	FF						x	x		x	x			x			
Nectarinia rufipennis	Jensen (1983)	E	VU	FF													x			
Nectarinia usambarica	Grote (1922)****	E		FF	x	xu	x	x	x											
Nectarinia fuelleborni	Reichenow (1899)****	NE		FF													x			x
*Oriolus chlorocephalus**	Shelley (1896)	NE	LC	F				x	x	x	x	x					x	x		
Ploceus nicolli	Sclater (1931)	E	EN	FF				x	x			x					x			
Poeoptera kenricki	Shelley (1894)	NE	LC	FF			x	x	x	x	x	x		x			x		x	x
Scepomycter winifredae	Moreau (1938)	E	VU	FF								x	x	x			x			
Serinus whytii	Shelley (1897)	NE	LC	NF										x			x			x
Serinus melanochrous	Reichenow (1900)	NE	LC	F										x			x			x
Sheppardia aurantiithorax	Beresford et al. (2004)	E		FF								x	x	x						
*Sheppardia lowei**	Grant and Mackworth-Praed (1941)	NE	VU	FF								xa					x			x
Sheppardia montana	Reichenow (1907)	E	EN	FF				x												
Sheppardia sharpei	Shelley (1903)	NE	LC	FF			x	x	x		x	x	xu	x			x			x
Sheppardia gunningi	Reichenow (1878)	NE	VU	FF						x								x		x
*Stactolaema olivacea**	Shelley (1880)	NE	LC	F				x	x	x	x	x	x	x			x	x		x
Swynnertonia swynnertoni	Shelley (1906)	NE	VU	FF					x								x			x
Turdus helleri	Mearns (1913)	E	CR	FF	x															
Turdus roehli	Reichenow (1905)§	E		FF		x	x	x	x											
Xenoperdix udzungwensis	Dinesen et al. (1994)	E	EN	FF													x			
Xenoperdix obscurata	Fjeldså and Kiure (2003)^	E	EN	FF										x						
Zosterops silvanus	Peter and Loveridge (1935)	E	EN	F	x															
Zosterops winifredae	Sclater (1935)	E	VU	F			x													
Mammals																				
Beamys hindei	Thomas (1909)	NE	NT	F			x	x	x	x	x	x	x	x	x		x	x	xu	x
Cephalophus spadix	True (1890)	NE	VU	FF				x				x					x		x	x
*Cercocebus sanjei***	Mittermeier (1986)	E		FF													x			
Congosorex phillipsorum	Stanley et al. (2005)	E		FF													x			
Crocidura desperata	Hutterer et al. (1991)	NE	EN	FF													x			x
Crocidura monax sensu lato	Thomas (1910)	NE	DD	FF				x	x	x	x	x	x				x		x	x
Crocidura tansaniana	Hutterer (1986)	E	VU	FF				x	x											
Crocidura telfordi	Hutterer (1986)	E	EN	FF								x					x			
Crocidura usambarae	Dippenaar (1980)	E	EN	FF			x	x	x											
Dendrohyrax validus	True (1890)	NE	VU	FF	x		x	x	x	x	x	x		x			x	x	x	
Galagoides orinus	Lawrence and Washburn (1936)	E	DD	FF					x		x	x		x			x			

(continued on next page)

Appendix 1 – *continued*

Species	Authority	Ende-mism	Threat status (November 2005)	Forest	Taita	North Pare	South Pare	West Usambara	East Usambara	Nguu	Nguru	Uluguru	Ukaguru	Rubeho	Malundwe	Mahenge	Udzungwa	Coastal Forests from Kenya to Mozambique	Kilimanjaro, Meru and/or Kenya Highlands	Southern Rift (inc. Rungwe, Matengo, Namuli, Nje, Malawisi)
Galagoides zanzibaricus	Matschie (1893)	NE	VU	FF					x			x					x	x		
Hylomyscus arcimontensis	Carleton and Stanley (2005)	NE		FF			x	x	x	x	x	x	x				x			x
Rungwecebus kipunji	Jones et al. (2005)	NE		FF													x			x
Myonycteris relicta[a]	Bergmans (1980)	NE	VU	FF					x			x					x	x		
Myosorex geata	Allen and Loveridge (1927)	E	DD	FF								x								
Myosorex kihaulei	Stanley and Hutterer (2000)	E	EN	FF													x			
Paraxerus vexillarius	Kershaw (1923)	NE	VU	FF				x	xu		x	x					x			x
Procolobus gordonorum	Matschie (1900)	E	VU	FF													x			
Rhinolophus deckenii	Peters (1867)	NE	DD	F					x						x			x	x	
Rhinolophus maendeleo	Kock et al. (2000)	NE	DD	FF					x									x		
Rhynchocyon petersi	Bocage (1880)	NE	EN	F		x	x	x	x	x	x	x					x	xb		
Sylvisorex howelli	Jenkins (1984)	E	VU	FF				x	x	x	x	x	x							
Reptiles																				
Adenorhinos barbouri	Loveridge (1930)	NE		f													x			x
Agama montana	Barbour and Loveridge (1928)	E		F					x		x	x					x			
Amblyodipsas teitana	Broadley (1971)	E		F	x															
Aparallactus werneri	Boulenger (1895)	NE		F		x		x	x			x						x	x	
Atheris ceratophora	Werner (1895)	E		F					x			x					x			
Buhoma procterae	Loveridge (1922)	E		FF								x					x			
Buhoma vauerocegae	Tornier (1902)	E		FF					x			x								
Chamaeleo deremensis	Matschie (1892)	E		FF					x		x	x								
Chamaeleo fischeri	Reichenow (1887)	E		FF				x	x		x	x								
Chamaeleo goetzei	Tornier (1899)	NE		NF													x			x
Chamaeleo laterispinis	Loveridge (1953)	E		F													x			
Chamaeleo oxyrhinum	Klaver and Böhme (1988)	E		FF							x	x		x			x			
Chamaeleo tempeli	Tornier (1899)	NE		F													x			x
Chamaeleo tenue	Matschie (1892)	E		F					x											
Chamaeleo werneri	Tornier (1899)	E		F							x	x	x	x			x			
Cnemaspis barbouri	Perret (1986)	NE		FF					x			x						x		
Cnemaspis uzungwae	Perret (1986)	NE		FF													x	x		
Crotaphopeltis tornieri	Werner (1908)	NE		FF				x	x		x	x		x			x			x
Dipsadoboa werneri	Boulenger (1897)	E		FF					x		x						x			
Elapsoidea nigra	Günther (1888)	E		F		x		x	x		x	x								
Gastropholis prasina	Werner (1904)	NE		F					x		x							x		
Leptosiaphos rhomboidalis	Broadley (1989)	E		FF													x			
Lycophidion uzungwense	Loveridge (1932)	E		F													x			
Lygodactylus conradti	Matschie (1892)	NE		FF					x									x		
Lygodactylus gravis[a]	Pasteur (1964)	NE		FF			x	x	x											
Lygodactylus uluguruensis	Pasteur (1964)	NE		F								x						x		
Lygodactylus williamsi	Loveridge (1952)	E		FF								x								
Melanoseps uzungwensis	Loveridge (1942)	E		FF													x			
Philothamnus macrops	Boulenger (1895)	NE		F					x	x	x						x	x		x
Prosymna ornatissima	Barbour and Loveridge (1928)	E		FF								x								
Prosymna semifasciata	Broadley (1995)	NE		FF					x									x		
Rieppeleon brevicaudatus	Matschie (1892)	NE		F					x		x	x				x	x	x		
Rhampholeon spinosum	Matschie (1892)	E		FF				x	x											
Rhampholeon moyeri	Menegon et al. (2002)	E		FF										xn		x	x			
Rhampholeon temporalis	Matschie (1892)	E		FF					x											
Rhampholeon uluguruensis (complex)	Tilbury and Emmrich (1996)	E		FF						x		x	x	x						
Rhampholeon sp. nov.	Matthee et al. (2004)	E		FF			x													
Rhinotyphlops nigrocandidus	Broadley and Wallach (2000)	E		FF								x	x				x			
Rhinotyphlops gierrai	Mocquard (1897)	NE		FF/F					x		xu							x		
Scelotes uluguruensis	Barbour and Loveridge (1928)	E		FF					x		x	x					x			
Tetradactylus udzungwensis	Salvidio et al. (2004)	E		NF													x			
Thelotornis usambaricus	Broadley (2001)	NE		F				x	x		x								x	
Typhlops uluguruensis	Barbour and Loveridge (1928)	E		F								x								
Typhlops usambaricus	Laurent (1964)	E		FF					x											
Urocotyledon wolterstorffi[a]	Tornier (1900)	NE		FF					x		x	x								
Xyeledontophis uluguruensis	Broadley and Wallach (2002)	E		FF								x								

Amphibians																				
Afrixalus uluguruensis	Barbour and Loveridge (1928)	NE	VU	FF				x	x	x	x	x	x			x	x	x		
Afrixalus morerei	Dubois (1986) "1985"	E	VU	f													x			
Arthroleptides martiensseni	Nieden (1910)	NE	EN	FF					x									x		
Arthroleptides yakusini	Channing et al. (2002)	E	EN	FF							x	x				x	x			
Arthroleptis affinis	Ahl (1939)	NE	LC	FF					x	x	x	x		x			x	x		
Arthroleptis reichei	Nieden (1910)	NE	NT	FF													x			x
Arthroleptis nikeae	Poynton (2003)	E	EN	FF										x						
Arthroleptis tanneri	Grandison (1983)	E	VU	FF				x												
Arthroleptis xenodactylus	Boulenger (1909)	E	VU	F					x											
Boulengerula boulengeri	Tornier (1896)	E	LC	FF				x	x											
Boulengerula niedeni	Müller et al. (2005)	E	VU	F	x															
Boulengerula taitanus	Loveridge (1935)	E	LC	F	x															
Boulengerula uluguruensis	Barbour and Loveridge (1928)	E	LC	F							x	x								
Bufo brauni	Nieden (1910)	E	EN	FF				x	x		x	x					x			
Bufo uzunguensis	Loveridge (1932)	NE	VU	NF													x			x
Callulina kisiwamsitu	De Sá et al. (2004)	E		FF				x												
Callulina kreffti	Nieden (1911) "1910"	E	LC	FF	x	x	x	xu	x	x	x	x	x				x			
Churamiti maridadi	Channing and Stanley (2002)	E	CR	FF									x							
Hoplophryne rogersi	Barbour and Loveridge (1928)	E	EN	FF					x	x										
Hoplophryne uluguruensis	Loveridge (1925)	E	VU	FF							x	x					x			
Hyperolius kihangensis	Schiøtz and Westergaard in Schiøtz (1999)	E	EN	FF													x			
Hyperolius puncticulatus	Pfeffer (1893)	NE	LC	F				x	x	x	x	x	x	x		x	x	x		x
Hyperolius minutissimus	Schiøtz (1975)	NE	VU	NF													x			x
Hyperolius spinigularis	Stevens (1971)	NE	LC	f				x	x		x	x					x	x		x
Hyperolius tannerorum	Schiøtz (1982)	E	EN	FF				x												
Hyperolius tornieri	Ahl (1931)	E	DD	F								x								
Leptopelis barbouri	Ahl (1929)	NE	VU	FF					x		x		x				x			x
Leptopelis uluguruensis	Barbour and Loveridge (1928)	E	VU	FF					x	x	x	x					x			
Leptopelis vermiculatus	Boulenger (1909)	NE	VU	FF				x	x	x	x		x			x	x			x
Leptopelis parkeri	Barbour and Loveridge (1928)	E	VU	FF			x	x	x			x					x			
Nectophrynoides asperginis	Poynton et al. (1999)	E	CR	NF													x			
Nectophrynoides cryptus	Perret (1971)	E	EN	FF								x								
Nectophrynoides frontierei	Menegon et al. (2004)	E	DD	FF					x											
Nectophrynoides laevis	Menegon et al. (2004)	E	DD	FF								x								
Nectophrynoides minutus	Perret (1972)	E	EN	FF								x		x						
Nectophrynoides poyntoni	Menegon et al. (2004)	E	CR	FF													x			
Nectophrynoides pseudotornieri	Menegon et al. (2004)	E	EN	FF								x								
Nectophrynoides tornieri	Roux (1906)	NE	LC	FF					x		x	x				x	x			x
Nectophrynoides vestergaardi	Menegon et al. (2004)	E	EN	FF				x												
Nectophrynoides viviparus	Tornier (1905)	NE	VU	F								x		x			x			x
Nectophrynoides wendyae	Clarke (1988, 1989)	E	CR	FF													x			
Parhoplophryne usambarica	Barbour and Loveridge (1928)	E	CR	F					x											
Phlyctimantis keithae	Schiøtz (1974)	E	VU	f													x			
Phrynobatrachus kreffti	Boulenger (1909)	E	EN	F		x		x	x											
Phrynobatrachus uzungwensis	Grandison and Howell (1983)	E	EN	FF						x	x	x					x			
Probreviceps macrodactylus	Nieden (1926)	E	VU	FF					x			x					x			
Probreviceps rungwensis	Loveridge (1932)	NE	VU	FF													x			x
Probreviceps uluguruensis	Loveridge (1925)	E	VU	FF								x								
Scolecomorphus kirkii	Boulenger (1883)	NE	LC	FF							x	x		x		x	x			x
Scolecomorphus uluguruensis	Barbour and Loveridge (1928)	E	LC	FF								x								
Scolecomorphus vittatus	Boulenger (1895)	E	VU	FF		x	x	x	x	x		x	x							
Spelaeophryne methneri	Ahl (1924)	NE	LC	F								x				x	x	x		x
Stephopaedes usambarae	Poynton and Clarke (1999)	E	EN	FF					x											

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Appendix 1 – *continued*

Species	Authority	Ende-mism	Threat status (November 2005)	Forest	Taita	North Pare	South Pare	West Usambara	East Usambara	Nguu	Nguru	Uluguru	Ukaguru	Rubeho	Malundwe	Mahenge	Udzungwa	Coastal Forests from Kenya to Mozambique	Kilimanjaro, Meru and/or Kenya Highlands	Southern Rift (inc. Rungwe, Matengo, Namuli, Nje, Malawisi)
Threatened animals in the Eastern Arc that are neither endemic nor near-endemic																				
Hirundo atrocaerulea˚	Sundevall (1850)	No	VU	NF													x			x
Otomops martiensseni	Matschie (1897)	No	VU	F					x								x	x		
Loxodonta africana	Blummenbach (1797)	No	EN	NF/f							x		x	x	x	x	X	x	x	x
Diceros bicornis	Linnaeus (1758)	No	CR	NF/f												xu	xu			
Panthera leo	Linnaeus (1758)	No	VU	NF/f											x		x			
Rhynchocyon cirnei	Peters (1847)	No	VU	F/f									x	x			x	x		x
Cinnyricinclus femoralis	Richmond (1897)	No	VU	F	x	x													x	

Key: Endemism – E = strictly endemic; NE = near-endemic (also found in at least one other African ecoregion); No = not endemic. Red List – threat codes according to the IUCN red list (accessed November 2005). CR = critically endangered, EN = endangered, VU = vulnerable, DD = data deficient, NT = near-threatened, LC = least concern, Blank = not evaluated. Forest – degree of forest dependence (FF = strictly confined to forest; F = mainly forest, but also found outside; f = forest visitor; NF = non-forest species). Records – x = confirmed presence; xa = record from the Andersen collection in Copenhagen; xb = recent camera trap photos cast doubt on taxonomy of these records; xn = new species in the process of being described, but retained within the original taxon for the purposes of this paper; xu = record uncertain (and not used for analysis); ** = species not formally described; *** = updated taxonomy in Roy et al. (1997) is not followed here; **** = taxonomy updated by Bowie et al. (2004); § = taxonomy updated by Bowie et al. (2004);^ = taxonomy updated by Bowie and Fjeldså (2005). ˚Distributional notes on some Eastern Arc near-endemic species that are found elsewhere in Africa.. *Oriolus chlorocephalus* = Southern Malawi into Mozambique, *Sheppardia lowei*, xa = Uluguru record from Andersen collection, *Stactolaema olivacea* = South Africa, *Hirundo atrocaerulea* = Udzungwa, Southern Rift, Uganda, South Africa, Malawi, *Myonycteris relicta* = also Haroni-Rusitu in Zimbabwe, *Lygodactylus gravis* = Maji Kununua (Mkomazi), *Urocotyledon wolterstorffi* = possible record from Arusha.

Appendix 2. Distribution of endemic and near endemic trees across the forests of the Eastern Arc Mountains

	Taita	North Pare	South Pare	West Usambara	East Usambara	Nguu	South Nguru	Uluguru	Ukaguru	Rubeho	Malundwe	Udzungwa	Mahenge	Near endemic
Anisophyllaceae														
Anisophyllea obtusifolia Engl. and Brehm.[§]					1		1					1		
Annonaceae														
Annonaceae gen. nov. = Ede 65[*]												1		
Anonidium usambarense R.E. Fries[§]					1									
Enantia kummeriae Engl. and Diels[§†]					1		1					1		
Greenwaydendron suaveolens (Engl. and Diels) Verdc. subsp. *usambaricum* Verdc.[§]				1	1									
Isolona heinsenii Engl. and Diels[§†]					1							1		Also coastal
Lettowianthus stellatus Diels *Φ*[†]					1	1		1				1	1	Also coastal
Polyceratocarpus scheffleri Engl. and Diels[§*]					1			1				1		
Uvariodendron gorgonis Verdc.[†]					1		1	1				1		Also coastal
Uvariodendron oligocarpum Verdc.[§]				1	1									
Uvariodendron pycnophyllum (Diels) R.E. Fries[§]				1	1									
Uvariodendron usambarense R.E. Fries[§]					1	1	1							
Araliaceae														
Polyscias stuhlmannii Harms[‡]	1			1			1	1	1					
Schefflera lukwangulensis (Tennant) Bernardi[‡]				1				1	1					
Celastraceae														
Platypterocarpus tanganyikensis Dunkley and Brenan[≥]				1										
Chrysobalanaceae														
Hirtella megacarpa R. Grah.[*]				1			1					1		
Clusiaceae														
Allanblackia stuhlmannii (Engl.) Engl.[§*]				1	1	1	1	1	1			1	1	
Allanblackia ulugurensis Engl.[*‡]							1	1				1		
Garcinia semseii Verdc.[§†]							1	1				1	1	
Mammea usambarensis Verdc.[*]			1	1										
Ebenaceae														
Diospyros kabuyeana F. White *Φ*					1		1	1				1		Also coastal
Diospyros occulta F. White[§] *Φ*[†]				1	1							1		Also coastal
Diospyros sp. aff. *amaniensis* Guerke[*]								1			1	1		
Euphorbiaceae														
Croton dictyophlebodes A.R.-Sm.[*≥]				1										
Drypetes usambarica (Pax) Hutch.[§†*]				1	1		1	1			1	1		Also coastal
Macaranga conglomerata Brenan[*]	1			1										
Sibangea pleioneura A.R.-Sm.[§]												1		
Fabaceae														
Angylocalyx braunii Harms *Φ*[†]					1		1					1		Also coastal
Cynometra brachyrrachis Harms[†]					1									Also coastal
Cynometra engleri Harms[†]					1									
Cynometra longipedicellata Harms[§]					1									
Cynometra sp. A[§]	1				1									
Cynometra sp. B[§]					1									
Cynometra ulugurensis Harms[†]								1						
Englerodendron usambarense Harms[§]				1	1									
Isoberlinia scheffleri (Harms) Greenway[†*]				1	1	1	1	1			1	1		Also coastal
Millettia elongatistyla Gillett[†]								1				1		
Newtonia paucijuga (Harms) Brenan[†]					1		1	1				1		Also coastal
Pterocarpus mildbraedii Harms subsp. *usambarensis* (Verdc.) Polhill[†]					1							1	1	
Scorodophloeos fischeri (Taub.) J. Léon. *Φ*[†]				1	1	1	1	1				1		Also coastal
Zenkerella capparidacea (Taub.) J. Léon.[§*]				1	1		1	1						
Zenkerella egregia J. Léon.[†]					1		1	1						Also coastal
Zenkerella perplexa Temu[§*]								1			1			

(*continued on next page*)

Appendix 2 – *continued*

	Taita	North Pare	South Pare	West Usambara	East Usambara	Nguu	South Nguru	Uluguru	Ukaguru	Rubeho	Malundwe	Udzungwa	Mahenge	Near endemic
Flacourtiaceae														
Dasylepis integra Warb.[*]	1			1	1									Also Mbulu
Casearia engleri Gilg[*‡]				1										
Lauraceae														
Beilschmidia kweo (Mildbr.) Robyns and Wilczek[§*]				1	1		1					1		
Melastomataceae														
Lijndenia brenanii (A. and R. Fernandes) Jacq. Fél.[§]					1									
Lijndenia greenwayii (Brenan) Borhidi[§]					1									
Memecylon sp. A[*]												1		
Memecylon teitense Wickens[*]	1													
Myristicaceae														
Cephalosphaera usambarensis (Warb.) Warb.[§]				1	1		1	1				1		Also Shimba Hills
Myrtaceae														
Syzygium micklethwaitii Verdc.[§*]	1			1								1		
Ochnaceae														
Ouratea scheffleri Engl. and Gilg[§]					1									
Ouratea schusteri Gilg ex Engl.[*]	1			1				1				1		
Octoknemataceae														
Octoknema orientalis Mildbr.[§]							1					1	1	
Pittosporaceae														
Pittosporum goetzei Engl.[‡]								1						
Rutaceae														
Calodendrum eickii Engl.[λ]				1										
Sapindaceae														
Allophylus melliodorus Radlk.[§*]					1		1					1		
Pancovia sp. B												1		Also North Malawi
Placodiscus amaniensis Radlk.[§]					1									
Placodiscus pedicellatus F.G. Davies[§]												1		
Sapotaceae														
Neohemsleya usambarensis Pennington[*]				1			1							
Omphalocarpum strombocarpum Y.B. Harv. and J.C. Lovett[§]												1		
Pouteria pseudoracemosa (J.H. Hemsl.) L. Gautier[§†]					1			1				1		
Sterculiaceae														
Cola scheffleri K. Schum.[§]				1	1							1		
Leptonychia usambarensis K. Schum.[§†*]	1			1	1	1	1	1	1			1		
Tiliaceae														
Grewia goetzeana K. Schum.[§]							1	1						Also coastal
Verbenaceae														
Vitex amaniensis Pieper[§*]					1		1	1				1		
Totals	8	0	1	27	40	6	25	26	4	0	4	36	5	

Notes on habitat associations: § = submontane forest; Φ = dry lowland forest; † = lowland forest; * = montane forest; λ = dry montane forest; ‡ = upper montane forest.

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